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Lawrence Livermore National Laboratory

Multifunctional Shock Tube Experimental Investigation of Gravitational Instabilities Evolution

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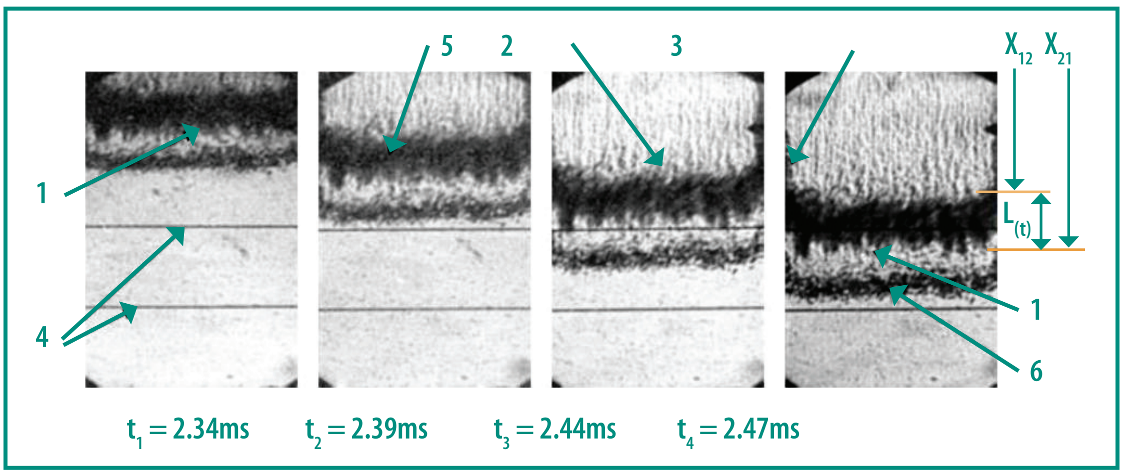
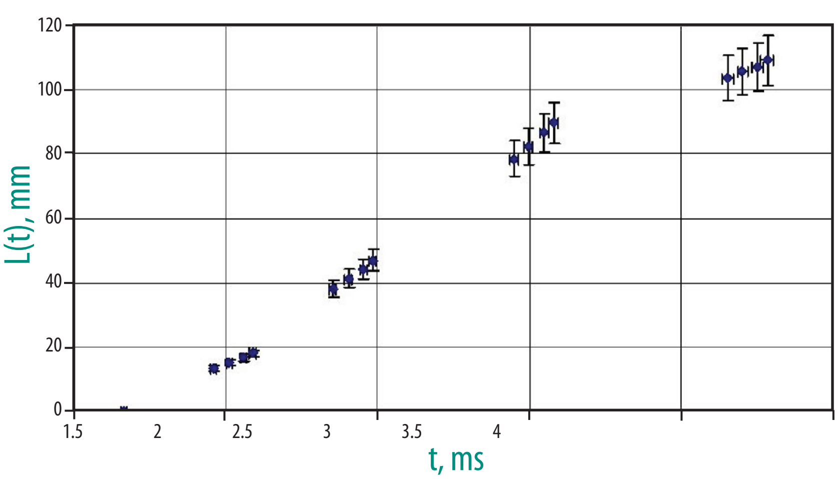
Project Description

The objective of this research is to experimentally determine the turbulent mixing properties under the combined action of the Richtmyer-Meshkov and Rayleigh-Taylor instabilities (which is characteristic of blast waves in supernovae) following the passage of a nonstationary shock wave through the interface separating two gases with different densities using the Multifunctional Shock Tube (MST) facility. The experiments were performed using gases with Atwood numbers $A = 0.21$ and $A = 0.82$ (air/carbon dioxide and helium/argon, respectively), where $A = (\rho_1 - \rho_2)/(\rho_1 + \rho_2)$. The Schlieren method was used to visualize the ensuing turbulent mixing of the gases. The time-evolution of the turbulent mixing layer width was determined in the light and heavy gases.

In this International Science & Technology Center (ISTC) Partner Project (Number 2716), the shock was explosively driven by detonating a mixture of hydrogen and oxygen, and a novel method of imposing perturbations on the thin nitrocellulose film separating the gases was used. The film was placed against a grid consisting of strong thin metal strings, and an electric current passing through the grid was used to destroy the film just as the shock arrived at the interface. Numerical simulations were performed to validate the design of the experiments.



Photographs of CO_2/He experiments: (1) mixing front in the light gas; (2) mixing front in the heavy gas; (3) wall flow; (4) scaled reference lines; (5) turbulent mixing layer; (6) fragments of nitrocellulose film.



Time-dependence of the average value of the turbulent mixing layer L(t). Error bars on the measurements are shown.

Technical Purpose and Benefits

This project carried out the first shock tube experimental investigation into the turbulent mixing evolution caused by the passage of a nonstationary shock wave through an interface separating two different density gases. The decaying shock wave accelerated the interface, thereby creating conditions for the development of both the Richtmyer–Meshkov and Rayleigh–Taylor instabilities. These experiments complement laser-driven experiments on blast wave instabilities by providing data on the qualitative structure of the mixing layer and the growth rate of the layer under a variety of conditions. Such experimental data can be used to validate numerical simulation codes that model Rayleigh–Taylor and Richtmyer–Meshkov instability-driven mixing.

Collaboration between Lawrence Livermore National Laboratory (LLNL), Livermore, CA, USA, and the Russian Federal Nuclear Center - All Russian Research Institute of Technical Physics (RFNC-VNIITF), Snezhinsk, Russia

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